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RESEARCH ARTICLE

Reproductive aspects of the Purple-throated Euphonia, *Euphonia chlorotica* (Aves: Fringillidae) in southeastern Brazil, and first record of the species nesting inside a vespiary

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ABSTRACT. Despite the fact that *E. chlorotica* (Linnaeus, 1766) is common and widely distributed in South America, the reproductive aspects of the species are poorly documented. Here we present data on 18 active nests found from August to February, between 2007 and 2012. Nests were globular with a lateral entrance, and measured 97.9 ± 14.4 mm in outside height, 110.6 ± 11.6 mm in outside diameter, and were 4.88 ± 2.09 m above ground. They were often supported from bellow and were composed mainly of tiny dry leafs and leaflets, fine petioles, and plumed seeds, all compacted with spider web silk. Eggs were laid on consecutive days or with one day interval, and clutch size varied from 1–3 eggs (2.1 ± 0.6, n = 9 nests). Only females incubated the eggs, but both sexes were involved in nest construction and nestling attendance at similar rates. Incubation and nestling periods were 14 and 21 days, respectively, and overall nest survival probability was 5%. A vespiary used for nesting was not occupied by wasps and nest material was deposited only to form the incubatory chamber. Although nesting near wasps or bees is a widespread strategy among birds in general, nesting inside the nests of social insects is a poorly documented behavior.

KEY WORDS. Birds, breeding biology, nesting behavior, Euphoniinae, wasps.

INTRODUCTION

Euphonias are small and conspicuous arboreal passerines, comprising 27 species that are restricted to the Neotropics (Hilty 2011). Sexual dimorphism is remarkable in most species, with males predominantly steely blue in the upperparts, and yellow in the underparts. Females, by contrast, are generally olive above and yellowish or grayish below (Sargent 1993, Ridgely and Tudor 1994, Sick 1997). These birds have been traditionally considered as Tanagers, but according to recent phylogenetic analyses they are finches of the family Fringillidae, where they compose the subfamily Euphoniinae together with the Chlorophonias (Zuccon et al. 2012). Distinctive features of the Euphonias and Chlorophonias are the highly specialized frugivorous diet, which is associated with the absence of gizzard in the Euphonias, and the construction of globular nests with side entrance (Isler and Isler 1999, Hilty 2011, Zuccon et al. 2012).

Many behavioral and ecological aspects of the Euphonias, including reproductive biology, remain poorly documented. The nests of twenty of the currently recognized species are known, and egg characteristics have been described for 15 species. Information on nest construction and parental care is available, in varying levels of detail, for 14 species, whereas incubation, and nestling periods are known for only five and four species, respectively (Nehrkorn 1910, Bertoni 1918, Bond 1943, Skutch 1945, 1985, Pinto 1953, Morton 1973, Ffrench 1980, Oniki and Willis 1983, 2003, Belton 1985, Isler and Isler 1999, and therein references, Pizo 2000, Greeney and Nunnery 2006, Solano-Ugalde et al. 2007, Janni et al. 2008, Kirwan 2009, Hilty 2011, and therein references, Marini et al. 2012).

Euphonia chlorotica (Linnaeus, 1766) is widely distributed in South America, occurring in most of Brazil, Guianas, and Paraguay, and in parts of Colombia, Venezuela, Peru, Bolivia, and Argentina. It inhabits forest borders, clearings, Cerrado, Caatinga (Ridgely and Tudor 1994, Sick 1997, Hilty 2011), and many types of secondary and anthropogenic habitats, such as orchards and urban vegetated areas. However, nesting information on this species is scattered and incomplete. Nests and/or egg descriptions, and data on clutch sizes, are given by Bertoni (1904), Snethlage (1928), De la Peña (1996), Lima (2006), Kirwan (2009), and Marini et al. (2012). Knowledge on parental activities is limited to the information that both males and females participate in nest construction (Oniki and Willis 1983, De la Peña 1996) and in nestling provisioning (Oniki and Willis 1983, Kirwan 2009), and incubation period is known from only one egg (Lima 2006).

Our specific goals in this paper were: 1) to provide supplemental information on nest, eggs, and nestling characteristics, clutch size, and incubation period; 2) to present for the first time information on nest measurements, nesting phenology, duration of the breeding season, nesting success, partitioning of parental activities, and the first nestling period, and 3) to provide the first report of a nest constructed inside a vespiary.

MATERIAL AND METHODS

Observations were conducted at the campus of Faculdade de Engenharia de Sorocaba (10.5 ha), Sorocaba, state of São Paulo, southeastern Brazil (23°28'S, 47°25'W), and at an adjacent smaller area (2 ha) of Cerrado sensu stricto, which was maintained within the urbanized area to protect a small and well-preserved stream. The campus presents extensive laws and gardens, with exotic trees, such as *Pinus* sp., *Eucalyptus* sp., *Mangifera* sp., and *Grevillea robusta* A. Cunn. ex R. Br., and also native trees typical of the Cerrado, with buildings and streets occupying about 30% of the area. The elevation is ~ 580 m asl., and the climate is classified as Cfa according to Koppen-Geiger (Kottek et al. 2006, Peel et al. 2007), with a humid, hot season from October-March (average rainfall 919 mm, and mean daily temperature ranging from 15.7 °C to 32.4 °C), and a dry, cold season from April-September (average rainfall 294 mm, and mean daily temperature ranging from 11.4°C to 30.6 °C).

Nests were routinely searched by walking along the whole area two to three times per week, from August to March, during three breeding seasons: 2007/2008, 2008/2009, and 2009/2010. Random searches were also performed in 2010/2011, and 2011/2012. Nests were found by following adults carrying material for nest construction, or delivering food to the nestlings (Martin and Geupel 1993), and monitored every 1–3 days since located. Nest type and egg shape were named following Winkler (2004), and they were measured with a caliper to the nearest 0.1 mm. Eggs were weighed to the nearest 0.1g with a spring scale. We analyzed nest material and took nest measurements only after nests were no longer being used.

The incubation period was considered from the first day of incubation to the day before hatching, and nestling period from the day of hatching to the day before fledging (Winkler 2004, Oliveira et al. 2010). As neither eggs nor nestlings were marked, we assumed that the first eggs to be laid were the first to hatch, and that the first young to hatch were the first to fledge (Davanço et al. 2013). Incubation and nestling periods were estimated based only on nests for which laying and hatchling dates, respectively, were known. We performed 1hr observation sessions in a number of nests to estimate the frequency at which adults deposited material during nest construction, the proportion of time invested in the incubation of the eggs, and the frequency of nestling provisioning by adults. The proportional investment in these activities by males and females were compared using Mann-Whitney test, implemented in the Software BioEstat 5.3 (Ayres et al. 2007). Descriptive statistics were provided as mean ± standard deviation.

We considered nest predation when eggs or nestlings disappeared from a nest before fledging age, and abandonment when adults were no longer seen near a nest for at least three days. We considered a success when young being fed outside a nest were observed. The probability of nest survival for the whole nesting cycle was estimated following the method proposed by Mayfield (1961).

RESULTS

We found 18 active nests during five breeding seasons: six in 2007/2008, five in 2008/2009, three in 2009/2010, two in 2010/2011, and two in 2011/2012. The earliest nesting activity was observed on 22 August 2007 (a nest in construction stage), and the latest nestlings were observed on 7 February 2009. Most breeding activities in the first three of these seasons occurred from September to November (Fig. 1).

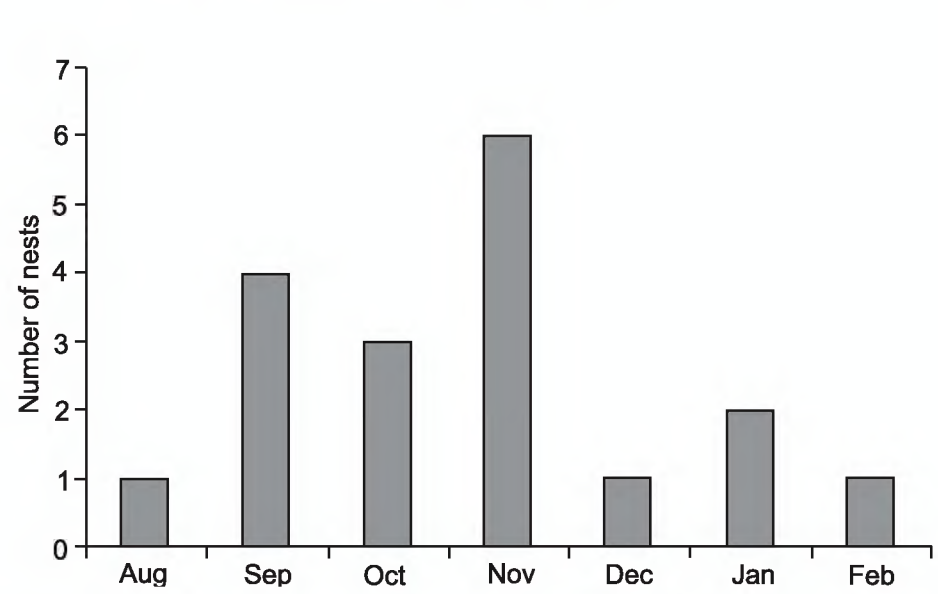

Figure 1. Monthly distribution of breeding activity of the Purple-throated Euphonia, from construction to nestling care, throughout three breeding seasons pooled together (2007/2008, 2008/2009, and 2009/2010).

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Figures 2–5. Nest, eggs and nestlings of the Purple-throated Euphonia. (2) A typical nest, globular with a lateral entrance, made of dry vegetal material kept together with spider web silk. (3) Partial view of the head of a female sitting in the incubatory chamber of an atypical nest constructed inside a vespiary. (4) Eggs are typically pyriform, with brownish marks that may be more or less concentrated around the large pole. (5) Older nestlings beg for food at nest entrance, showing their red mouth lining and white oral flanges to their mother.

Nests were globular, but sometimes laterally flattened to adapt to the supporting branches. Nest wall was composed mainly of tiny dry leaves and leaflets, fine petioles, and plumed seeds, all highly compacted with a great amount of spider web silk. Pine needles and a few small stripes of dry grass were also found in some nests. Large dry leaves could be present, and all nests were dark brown externally (Fig. 2). The incubatory chamber was lined with very thin, light brown vegetal fibers, including peduncles of grass inflorescences, palm fibers, plumed seeds, and in one case, a few small feathers. The lateral entrance was well delimited by flexible fibers placed around it, and although the entrance was round in the beginning, it became elliptical in late nesting stages, as nest roof tended to collapse during the nesting cycle. Nests were supported from below by a larger branch or fork, and often also laterally by a number of smaller branches or leaves. One nest, however, was hung from the tip of a descending branch of *Pinus* sp., to which it was attached only laterally. Another nest was constructed inside a large, tri-dimensional spider web, and it was totally supported by it. In this case, dry leaves of *G. robusta* fell down with the wind and remained attached to the spider web, serving to camouflage the nest. Measurements of six nests were 97.9 ± 14.37 mm (range = 77.5–114.7) in outside height, 110.61 ± 11.56 mm (range = 97.5–130.0) in outside diameter, 54.1 ± 4.55 mm (range = 48.9–57.4) in inside height,

and 71.76 ± 7.34 mm (range = 64.0–78.6) in inside diameter (n = 6). The ellipsoid nest entrances measured 43.7 ± 3.04 (range = 39.1–46.5) x 28.45 ± 3.11 mm (range = 25.0–33.3) (n = 6), and the mean height of nests above ground was 4.88 ± 2.09 m (range = 2.25–9.0) (n = 9). Nesting trees were 2.75 to 17 m high (11.4 ± 5.4 m), and included *Pinus* sp. (n = 8), *G. robusta* (n = 3), *Yucca* sp. (n = 3), *Copaifera langsdorffii* Desf. (n = 1), *Caesalpinia peltophoroides* Benth. (n = 1), and *Gochnatia polymorpha* (Less.) Cabrera (n = 1). Three nests were deposited in the Ornithological Collection of the Museu de Zoologia da Universidade de São Paulo – MZUSP, under voucher numbers 2.283, 2.284, and 2.285.

Notably, in 2010 a female was found incubating two eggs in a nest constructed inside an abandoned nest of unidentified wasps. The vespiary was hung from a horizontal branch of *G. robusta* and it was very similar in size, shape (globular), and color to the nests of Purple-throated Euphonias (Fig. 3). Based on the size and round format of the entrance, and on the globular shape of the incubatory chamber, we believe that it was excavated by the birds and not by other animals. Nest material was deposited only to construct the incubatory chamber, and was similar to that we found in the other nests.

During nest construction, both males and females carried and deposited nest materials, and both were observed performing body movements to shape the incubatory chamber. In 16 hours of observation at nine nests, females brought nest material 1 to 21 times per hour, and males 0 to 14 times per hour, but the number of visits did not differ significantly between sexes (females 6.50 ± 5.09 times/hour, males 4.44 ± 4.15 times/hour, U = 94, p = 0.2). Notably, in 18% of the visits adults were observed carrying spider web stripes in their beaks that could be much longer than their own bodies (i.e. 15 cm), or they carried tufts of this material wrapped in the breast and belly. Clutch sizes were 1 (n = 1), 2 (n = 6) or 3 eggs (n = 2) (2.1 ± 0.6). Eggs were pyriform, with white background color, and dark and light brown blotches and spots, that could be round or elongated. These markings could be concentrated in the large end, or they could form a wreath near the large pole (Fig. 4). Egg measurements were (n = 5 eggs from two nests): length 16.24 ± 1.35 mm (range: 15–17.8), width 12.04 ± 0.09 mm (range = 11.9–12.1), and weight 1.16 ± 0.13g (range: 1–1.3).

In three nests, eggs were laid on consecutive days, and in one nest with one day interval. In these nests, incubation started the day the last egg was laid. In another nest in which only one egg was laid, incubation started two days later. Incubation period was 14 days (n = 2 eggs from one nest). In 16 hours of observation in seven nests, only females were recorded incubating the eggs. Average time spent incubating was 28.27 ± 17.34 min per hour (range = 0–57.57), females left the nests 1.2 ± 0.75 times per hour (range = 0–2), and incubation recesses lasted 11.55 ± 12.95 min (range = 0.87–60).

Hatching was synchronous (n = 2 nests) and nestling period was 21 days (n = 2 young from one nest). Hatchling skin was dark red with sparse gray down, and nestling presented bright red mouth lining and white swollen flanges (Fig. 5). In 13 hours of observation in five nests, nestlings were provisioned on average 4.84 ± 1.90 times per hour (range = 2–8), with equal participation of both sexes (females 2.69 ± 1.23 times/hour, males 2.15 ± 1.06 times/hour, U = 70, p = 0.10). Females brooded the young after provisioning until they were around 10 days old, and after that they were fed from the nest entrance, and their heads could be seen from outside while begging for food (Fig. 5). Of the 18 nests, three were abandoned in construction stage, and two were not monitored for success. Of the remaining 13 nests, two were abandoned during incubation, one was abandoned in unknown stage, two (including the nest constructed inside the vespiary) were predated in incubation stage, four were predated in nestling stage, and four fledged young. Mayfield average nest survival probability was 5% (three abandonments and six predations in 110 nest days).

DISCUSSION

The nesting season in our study area matched most of the records of active nests of the Purple-throated Euphonia from other localities, i.e. one nest recorded in late November in Paraguay (Bertoni 1904), one nest found in October in Santa Fé, Argentina (De La Peña 1996), one nest found in December in Bahia, northeastern Brazil (Lima 2006), and two nests found in September/October in Distrito Federal, Central Brazil (Marini et al. 2012). However, Kirwan (2009) observed a nest with nestlings on 7 August 2007 in the state of Mato Grosso, Brazil, meaning that breeding activities may have started in June, and in Manaus, northern Brazil, Oniki and Willis (1983) observed a nest that was active at least from 21 April (in construction) to 25 May 1974 (nestlings), indicating that the breeding season can be different in other South American regions.

Nest shape followed the general pattern found for other Euphoniinae, but nest materials used by the Purple-throated Euphonia have been only superficially described so far, impeding detailed comparisons with other regions. However, the use of materials of the supporting plants, also reported by other authors, may be an important source of variation in nest composition. Although we report the use of a spider web for the first time, we believe that this material may have been used also in the previously described nests, as it seemed to be an indispensable component to construct a globular structure using such small vegetal materials as those reported here. Although Bertoni (1904) has mentioned the presence of a false entrance on the top of a nest, and Kirwan (2009) has suspected, based on parental movements, that a nest observed in Mato Grosso could have a similar structure, we never found it in the nests we studied. The nest reported by De La Peña (1996) from Santa Fé, Argentina, was a deep cup, differing from the typical globular shape known for the entire subfamily, and seemed to be a rare exception.

The presence of nests among the leaves of a bromeliad (Oniki and Willis 1983), inside a spider web, as well as the use of other

supporting plants, i.e. Urucum, *Bixa orellana* (Lima 2006), indicate that the Purple-throated Euphonia is a generalist with respect to nesting support, but the construction of a nest inside a vespiary was an unexpected finding. Other species of *Euphonia* have been recorded constructing their nests in abandoned structures made by other animals. For instance, Violaceous Ephonias *E. violacea* (Linnaeus, 1758), and Thick-billed Euphonias *E. laniirostris* (d'Orbigny and Lafresnaye, 1837) were observed, respectively, building their nests inside old nests of the Rusty-margined Flycatcher *Myiozetetes cayanensis* (Linnaeus, 1766) (Snethlage 1935, Oniki and Willis 2003), and of the Great Kiskadee *Pitangus sulphuratus* (Linnaeus, 1766) (Skutch 1969), and Skutch (1954) reported a pair of the Yellow-crowned Euphonia *E. luteicapilla* (Cabanis, 1861) constructing a nest "in a pocket between the layers of brood-cells in an old wasps' nest". In all of these cases the abandoned structures served as protection or support, and Euphonias have constructed the entire structure of their own nests. Our case is different because the vespiary itself served as the nest wall, and the only building material carried by the birds was that used for lining of the incubatory chamber. We do not believe this was an anti-predatory strategy, because the vespiary was inactive, and there is no evidence from other nests of an association between Purple-Throated Euphonias and wasps or bees. Although the association of nesting birds with venomous insects is a relatively common strategy (see Hansell 2002 for a review), nesting inside the structures constructed by these insects seems to be very uncommon. To our knowledge, the only other reported case for Neotropical birds was that of a Violaceous Trogon *Trogon violaceus* (Gmelin 1788) which also nested inside a vespiary (Skutch 1976).

The clutch sizes of Purple-throated Euphonias were similar to those reported by other authors, being three eggs in the nest found by De La Peña (1996), three in the nest found by Lima (2006), and two in each of the two nests found by Marini et al. (2012). Among the Euphonias, six of the species with known nests have exceptionally large clutch sizes of four to five eggs (Barnard 1954, Sargent 1993). Among birds, in general, closed nesters tend to present larger clutch sizes, but 4–5 eggs is too large compared to most of the Neotropical closed-nester species (see Sargent 1993). Clutch sizes reported for the Purple-throated Euphonia, as well as for some other species of the genus, as the Chestnut-bellied Euphonia *E. pectoralis* (Latham, 1801) (Isler and Isler 1999, Pizo 2000), and the Golden-rumped Euphonia *E. cyanocephala* (Vieillot, 1818) (Hilty 2011), fall within the regular range of 2–3 eggs expected for Neotropical passerines, indicating that exceptionally large clutch sizes is not a characteristic disseminated among the whole genus. Notably, some of the species that lay large clutches are from equatorial regions as the Yellow-throated Euphonia *E. hirundinacea* (Bonaparte, 1838) (mostly 5 eggs) (Sargent 1993) and the Jamaican Euphonia *E. jamaica* (Linnaeus, 1766) (3–4 eggs) (Bond 1961, March 1863), whereas smaller clutch sizes have been reported for some species or populations from tropical/subtropical locations i.e. the Orange-bellied Euphonia *E. xanthogaster* (Sundevall, 1834) (3 eggs) (Solano-Ugalde et al. 2007), and the Violaceous Euphonia (2 eggs in Southeastern Brazil) (Pinto 1953). This counteracts the general theory of larger clutch sizes in higher latitudes, observed in all of the continents (Jetz et al. 2008), indicating that other ecological and evolutionary aspects may be involved in this variation, which deserves investigation.

Although our data on incubation and nestling periods are based on a single nest, together with the incubation period of one egg provided by Lima (2006), these are the only information available so far. Assuming that incubation has started in the day the last egg was laid (as often observed here), and using our method of estimation, the incubation period presented by Lima (2006) would be 13 days. Thus, nesting cycle of the Purple-throated Euphonia was similar to that observed for the Yellow-throated Euphonia (14–16 days of incubation, and 18–20 days of nestling period: Skutch 1945, 1954, Sargent 1993), for the White-vented Euphonia *E. minuta* (Cabanis, 1849) (15–17 days, and 18–20 days, respectively: Skutch 1972, 1976), and for the Yellow-crowned Euphonia (13–14 days, and 22–24 days, respectively: Skutch 1954).

Many bird species can benefit from reproducing in anthropic habitats, where nest survival can be higher due to the increased protection provided by man-made structures, or due to the absence of certain nest predators (Møller 2010). However, nest survival in our study population was very low when compared to other passerines studied in urban parks or university campuses in southeastern Brazil, e.g. the Lined Seedeater *Sporophila lineola* (Linnaeus, 1758) (40%: Oliveira et al. 2010), the Yellowish Pipit *Anthus lutescens* (Pucheran, 1855) (87.0%: Freitas and Francisco 2012a), the Grassland Yellow-Finch *Sicalis luteola* (Sparrman, 1789) (47.0%: Freitas and Francisco 2012b), the Pale-breasted Thrush *Turdus leucomelas* (Vieillot, 1818) (54%: Davanço et al. 2013), and the Red-crested Finch *Coryphospingus cucullatus* (Statius Müller, 1776) (28.2%: Zima and Francisco 2016). Although some Euphonias seem to be dependent on specific habitats, the Purple-throated Euphonia has adapted to disturbed areas, but our data provide evidence that at least some of the areas inhabited by this species may act as reproductive traps (for a review see Battin 2004). Despite nests and eggs having been described for most of the species of *Euphonia*, this genus is still poorly known in terms of other reproductive aspects. Due to their widespread distribution and apparent geographic variations in reproductive parameters, such as clutch size and breeding phenology, gathering data on multiple populations and species of Euphonia may permit to test important theories about Neotropical birds life history evolution (Davanço et al. 2013), and the information presented here is a contribution to fill these knowledge gaps.

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